I J R B A T, Issue (X) Vol (III) Sept 2022: 8-13
A Double-Blind Peer Reviewed & Refereed Journal
OPEN ACCESS
e-ISSN 2347 – 517X
Original Article

INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY
 www.ijrbat.in

STUDIES ON PRE AND POST INFECTION MANAGEMENT EFFICIENCY OF FUNGICIDES AGAINST PHYTOPHTHORA CAPSICI IN BLACK PEPPER

C. R. Rini*, P.M. Ajith, G. Jayakumar and V.R. Shajan
Agricultural Research Station, KAU, Thiruvalla – 689102, Kerala.

Communicated :17.04.2022 | Revision : 16.05.2022 & 17.06.2022 Accepted :12.07.2022 | Published: 30.09.2022

ABSTRACT: Foot rot caused by *Phytophthora capsici* is the most destructive disease of black pepper (Piper nigrum L.) and it affects the total production in all black pepper growing areas. Despite many fungicidal recommendations, the disease control is still a matter of concern. Hence it is important to incorporate more effective fungicides in the disease management plan. In the present study, twelve different fungicides and a microbial consortium were evaluated for their efficiency in suppressing P. capsici in black pepper. Fungicides differ in their efficiency in reducing P. capsici infection when applied before and after infection initiation. Dimethomorph 9% + Mancozeb 60% WP and Fosetyl Al 80%WP were found to be the best fungicides to manage the disease prophylactically as well as after the commencement of disease. Cymoxanil 8% + Mancozeb 64% WP, Fenamidone 10% + Mancozeb 50% WG, Kresoxim methyl 44.3% SC and Iprovalicarb 5.5% + Propineb 61.25% WP also provided more than 80% control when applied prophylactically and 50% or more control when applied after initiation of the disease. Application of microbial consortium was found effective only when applied prophylactically.

Key words: - Black pepper, *Phytophthora* foot rot, Management, Fungicides, Biopesticide.

INTRODUCTION:

Black pepper (*Piper nigrum* L.), the 'King of Spices' is an important agricultural commodity of trade in India since pre- historic times. The crop is known to be affected by a number of biotic and abiotic stresses. Among the major diseases, foot rot caused by *Phytophthora capsici* is the most destructive one which affects the total production in all black pepper growing areas. It is a debilitating disease that affects the survival of the crop (Ravindran, 2000). The pathogen is versatile in nature and infects all parts of the vine *i.e.* root, collar, stem, leaves, inflorescence and spike. It is a soil borne fungus and can survive in infected plant debris for long period and hence single method is not effective in checking the disease. Therefore, an integrated approach comprising phytosanitary measures, cultural, chemical, biological, resistant/tolerant cultivars is necessary for successful management of this disease (Anandaraj, 2000). However, use of fungicides forms the major component in disease management strategy. Copper based fungicides, Metalaxyl and Potassium phosphonate are now being recommended for the management of this disease (Anandaraj, 2000; KAU, 2016). However, use of copper based fungicides or postassium phosphonate do not give satisfactory control of the disease particularly after its onset. *P. capsici* is a multi-cyclic oomycete pathogen and quickly develops resistance to fungicides (Gisi and Cohen 1996). It is reported that extensive application of Metalaxyl has resulted in widespread resistance to this fungicide in field (Rende *et al.* 2012; Raymond *et al.* 2015). Over the past two decades, several fungicides have been developed for management of oomycete pathogens, including *Phytophthora* spp. (Thind, 2011). Hence it becomes the need of the hour to

incorporate more fungicides in the disease management plan. With this background, we have undertaken this work to study the pre and post infection management efficiency of some commercially available fungicides and biopesticide to manage Phytophthora infection in black pepper.

MATERIALS AND METHODS:

Isolation of test pathogen and preparation of zoospore suspension

Phytophthora capsici was isolated from the diseased leaf samples of black pepper collected from the experimental farm of Pepper Research Station, Panniyur. Koch's postulates were proved and the virulent isolate was maintained in Carrot agar slants at 25°C. Zoospore suspension of *P.capsici* was prepared based on the methods described by Fitzpatrick-Peabody (2011) with slight modification. The pathogen was grown in Carrot Agar medium and incubated in dark for three days at 22°C for vegetative growth. Bits of the pathogen were transferred to sterile petriplates containing sterile distilled water with mycelium side upwards. The water level was adjusted in such a way that the bits are not submerged. The plates were then kept at fluorescent light for three days for sporangial production. To induce zoospore release, cultures were chilled at 4° C for one hour and brought to room temperature in the darkness. Zoospore release occurred in 15 to 20 minutes. The suspension was collected and shook well to sediment the zoospores.

***In planta* evaluation of fungicides as prophylactic spray**

Twelve different fungicides *viz.*, Bordeaux mixture, Copper hydroxide 77% WP (Kocide), Cymoxanil 8% + Mancozeb 64% WP (Curzate), Dimethomorph 9% + Mancozeb 60%WP (Acrobat MZ), Fenamidon 10% + Mancozeb 50% WG (Sectin), Fosetyl Al 80%WP (Aliette), Iprovalicarb 5.5% + Propineb 61.25% WP (Melody Duo), Kresoxim methyl 44.3% SC (Ergon), Potassium Phosphonate (Akomin), Propineb 70% WP (Anthracol), Trifloxystrobin 25% + Tebuconazole 55% WG (Nativo) and a consortium of plant growth promoting microorganisms (PGPM) was selected and tested against *Phytophthora* infection in black pepper. Consortium of PGPM consisting of four different microorganisms viz., *Trichoderma viride*, *Trichoderma harzianum*, *Pseudomonas fluorescens* and *Bacillus megatherium* developed by Kerala Agricultural University was used in this study. Four month old healthy rooted cuttings of var. Panniyur 1 served as the test plant for the experiment. The test fungicides and biopesticide at prescribed concentration (Table 1) were sprayed on both sides of the leaves of black pepper plants and kept in shade for 24 hours. The plants were challenge inoculated by spraying with zoospore suspension of *P.capsici*, adjusted to a population of 10^4 zoospore/ml. After inoculation the whole plant was covered with polythene bag having fine pin holes. A moistened cotton pad was placed inside the bag for maintaining humidity to initiate infection. *P. capsici* inoculated plants without any fungicidal spray served as control. The treated plants were kept in shade under green house condition and arranged in completely randomized design with three replications. Observations were recorded on 4th day of inoculation. Twenty five leaves were evaluated in each treatment. The plants were rated based on the infected leaf area and had given scores using a score chart of 0-5 scale. On the 0-5 scale, 0 = No infection; 1 = 1-10% infection; 2 = 11-25% infection; 3 = 26-50% infection; 4 = 51-75% infection and 5 = more than 75% infection. Percent disease intensity was calculated using the formula (Singh 1984) and statistically analyzed.

$$\text{Percent Disease Intensity (PDI)} = \frac{\text{Sum of all numerical ratings} \times 100}{\text{Total number of leaves observed} \times \text{Maximum disease score}}$$

***In planta* evaluation of fungicides as post infection spray**

The fungicides tested in the above experiment were further tried as post infection spray to see their effect to bring *Phytophthora* infection under control after the onset of the disease. For this, four month old rooted cuttings of var. Panniyur 1 were prior inoculated with *P.capsici* zoospore suspension as described earlier. The inoculated plants were bagged with polythene covers and kept in shade for 48 hrs for the infection to take place. As disease appeared, the test fungicides and biopesticide at prescribed concentration (Table 1) were sprayed on both sides of leaves after removing the bag cover. The plants were again covered with polythene bags for maintaining amiable conditions for advancement of infection. *P. capsici* inoculated plants without any fungicidal spray served as control. The treated plants were arranged in completely randomized design with three replications and kept in shade under green house condition. On 4th day, the plants were observed for the severity of infection. The plants were rated based on the infected leaf area and had given scores using a score chart and percent disease intensity was calculated as explained earlier. The data were subjected to Analysis of Variance Technique using Web Agri Stat Package (WASP 2.0)

RESULTS AND DISCUSSIONS :

The data (Table 1) showed that all test fungicides were significantly superior over control in preventing disease when applied as prophylactic spray as evidenced by very less infection on leaves. With these fungicides, disease intensity ranged from 0-30% on 5th day of inoculation whereas in control PDI recorded was 65% *ie.*, more than 50% reduction over control could be achieved with all fungicides. Among them dimethomorph 9% + mancozeb 60% WP, fosetyl Al 80%WP and bordeaux mixture recorded 100% protection to the plants with no infection when applied as prophylactic spray. Similar results were reported by Matheron and Porchas (2015) where, dimethomorph, individually or in combination with other fungicides effectively reduced the plant mortality due to *P. capsici* infection. Next best fungicides observed were fenamidone 10% + mancozeb 50% WG, kresoxim methyl 44.3% SC and iprovalicarb 5.5% + propineb 61.25%WP with 92.3% reduction in disease as compared to control. These fungicides recorded a PDI of 5% as against 65% PDI in control on the day of observation. Cymoxanil 8% + mancozeb 64% WP, potassium phosphonate and copper hydroxide 77% WP were also found promising with more than 80% reduction over control. Rini and Ramya (2020) conducted field experiments and reported that prophylactic spraying with Fenamidone 10WG + Mancozeb 50WG or Copper hydroxide 77 WP @ 0.2% during 1st week of June, August and October can effectively manage the natural incidence of Phytophthora foot rot in black pepper under field conditions. Dimethomorph + Mancozeb and Cymoxanil + Mancozeb were also found better than the existing recommendation of Bordeaux mixture spray and Copper oxy chloride. Bhai and Anjali (2015) observed that foliar spray of Kresoxim methyl 44.3% SC followed by challenge inoculation with *P. capsici* resulted in overall reduction in lesion development by 44.83% over control and maximum inhibition 57.12% at five days after spraying at a concentration of 7000 ppm. The effect of PGPM consortium as protective spray was comparable with that of the chemical fungicides as indicated by less disease intensity. With PGPM, PDI recorded was only 15% *ie.,* 76.9% less infection than the control. Use of biocontrol agents in combination for controlling nursery rot disease of black pepper was reported by Anith and Manomohandas (2001).

The test fungicides showed variation in their effectiveness when they were applied after the establishment of disease. Some fungicides which were highly effective as prophylactic spray did not combat the disease to that extent when applied after commencement of infection. Only seven fungicides viz., Dimethomorph 9% + Mancozeb 60% WP, Fosetyl Al 80%WP, Cymoxanil 8% + Mancozeb 64% WP, Fenamidone 10% + Mancozeb 50% WG, Kresoxim methyl 44.3% SC, Iprovalicarb 5.5% + Propineb 61.25% WP and Propineb 70WP recorded 50% or more reduction in disease intensity when applied after commencement of the disease. Dimethomorph 9% + Mancozeb 60% WP and Fosetyl Al 80%WP were found to be best fungicides against *P. capsici* with 74.3 and 71.8% reduction in disease severity respectively when applied on diseased plants. Mohammad and Jose (2018) suggested dimethomorph as one among the best fungicides for controlling *P. capsici* under *in vitro* and field. Next alternatives for eradicant spray observed were Cymoxanil 8% + Mancozeb 64% WP, Fenamidone 10% + Mancozeb 50% WG, Kresoxim methyl 44.3% SC and Iprovalicarb 5.5% + Propineb 61.25% WP. Rende *et al.* (2012) reported that the strobilurins viz., azoxystrobin and trifloxystrobin provided over 80% efficacy while propamocarb and cymoxanil provided 70% or more efficacy in controlling Pepper Phytophthora blight. Spraying with Bordeaux mixture, Copper hydroxide 77% WP, Potassium phosphonate and Copper oxy chloride 50% WP after the onset of disease did not suppress the disease progress to a satisfactory level as they recorded comparatively high intensity of disease. The efficacy of PGPM consortium in suppressing the pathogen after commencing the disease was not as encouraging as it could reduce the severity only upto 7.9%. The effect of Bordeaux mixture and copper oxy chloride in Phytophthora foot rot management and widely accepted among farmers is well documented by Anandaraj and Sarma (1995) and KAU (2016). KFRI (1996) reported that during heavy monsoon fungicides like Copper oxychloride do not give satisfactory control of the disease particularly after the onset of disease.

CONCLUSION:

Since fungicides are the last resort and expensive components of disease management strategy, it is very important that the fungicides chosen should give adequate protection to the plant and effectively control the pathogen. Hence, it is necessary that more effective fungicides must be incorporated in the management plan and needs to be alternated to prevent development of resistance. The study reveals the efficacy of newer fungicides which could be incorporated in the spray schedule which has the capacity of preventing as well as eradicating the pathogen for better disease management. But more studies are required to validate the results under field condition before going to recommendation.

ACKNOWLEDGEMENT:

The authors are thankful to Kerala Agricultural University for the facilities provided for conducting the work.

REFERENCES:

Anandaraj, M. and Sarma, Y. R. (1995). Diseases of black pepper (Piper nigrum L.) and their management. J. Spices Arom. Crops. 4: 17-23.

Anandaraj, M. (2000). Diseases of black pepper. In Ravindran P N (Ed.) Black Pepper (Piper nigrum). Harwood Academic Publishers. pp. 245-275

Anith, K.N. and Manomohandas, T.P. (2001). Combined application of Trichoderma harzianum and Alcaligenes sp. strain AMB 8 for controlling nursery rot disease of black pepper. Indian Phytopathol. 54:335-339.

Bhai, R. S. and Anjali, C. R. (2015). Evaluation of strobilurin fungicide Ergon 44.3% (w/w) [Kresoxim methyl 500g L-1 SC] and RIL-070/FI (72 WP) against Phytophthora capsici infection in black pepper. J. Spices Arom. Crops. 24: 73-82.

Fitzpatrick-Peabody, E. (2011). Methodology and assessment of the susceptibility of potato genotypes to Phytophthora erythroseptica causal prganism of pink rot. Am. J. Potato Res. 88:105–113.

Gisi, U. and Cohen, Y. (1996). Resistance to phenylamide fungicides - A case study with Phytophthora infestans involving mating type and race structure. Annu. Rev. Phytopathol. 34: 549-572.

KAU, (2016). Package of Practices Recommendations: Crops. 15th edition. Directorate of Extension, Kerala Agricultural University, Thrissur.

KFRI, (1996). Fungicidal management of quick wilt disease of black pepper in forest plantations. KFRI Research Report 111, Kerala Forest Research Institute, Peechi, Thrissur.

Matheron, M. E. and Porchas, M. (2015). Effectiveness of nine different fungicides for management of crown and root rot of Chile pepper plants caused by Phytophthora capsici. Plant Health Progress 16: 218-222.

Mohammad, B. and Jose, R. D. S. (2018). Chemical Management of Phytophthora capsici in Pumpkin in Illinois. Mod Concep Dev Agrono. 1: 78 -82.

Ravindran, P. N. (2000). Constraints and yield gaps in Black pepper. In Ravindran P N (Ed.) Black Pepper (Piper nigrum) . Harwood Academic Publishers. pp. 497-504.

Raymond, F. C., Gillian, F. and Craig, M.N. (2015). Management of phytophthora blight (Phytophthora capsici) on vegetables in Ontario: Some greenhouse and field aspects. Can. J. Pl. Pathol. 37: 1-20

Rende, Q., Tao, W., Wei, Z., Ping, L., Jiancheng, D. and Zhimou, G. (2012). Activity of ten fungicides against Phytophthora capsici isolates resistant to metalaxyl. J. Phytopathol. 160: 11-12

Rini, C. R. and Remya, J. (2020). Management of Phytophthora capsici Infection in Black Pepper (Piper nigrum L.) using New Generation Fungicides and Biopesticide. Internat. J. Agric. Environ. Biotech. 13: 71-74.

Singh, R. S. (1984). Introduction to Principles of Plant Pathology. Oxford and IBH Publshing Co. Pvt. Ltd. New Delhi.

Thind, T. S. (2011). New generation anti - oomycete fungicides: Prospects and limitations. Pl. Dis. Res. 26: 159.

Table 1. Disease management efficacy of different fungicides and biopesticide against *Phytophthora capsici.*

Fungicides	**Trade name**	**Concentration (%)**	**Prophylactic spray****		**Post infection spray****	
			Percent Disease Intensity*	% reduction over control	Percent Disease Intensity*	% reduction over control
Bordeaux mixture	Bordeaux mixture	1.0	0 (0.26)^{a}	100.0	45.9 (42.65)^{cd}	44.6
Copper hydroxide 77% WP	Kocide	0.2	10 (18.38)^{c}	84.6	45.7 (42.53)^{cd}	44.9
Copper oxy chloride 50% WP	Fytran	0.2	20 (26.45)^{e}	69.2	46.7 (43.09)^{cd}	43.6
Cymoxanil 8% + Mancozeb 64% WP	Curzate	0.2	10 (18.38)^{c}	84.6	33.3 (35.22)^{b}	59.7
Dimethomorph 9% + Mancozeb 60%WP	Acrobat MZ	0.2	0 (0.26)^{a}	100.0	21.3 (27.42)^{a}	74.3
Fenamidon 10% + Mancozeb 50% WG	Sectin	0.2	5 (12.75)^{b}	92.3	33.3 (35.22)^{b}	59.7
Fosetyl Al 80%WP	Aliette	0.1	0 (0.26)^{a}	100.0	23.3 (28.80)^{a}	71.8
Iprovalicarb 5.5% + Propineb 61.25% WP	Melody Duo	0.2	5 (12.92)^{b}	92.3	36.7 (37.28)^{b}	55.7
Kresoxim methyl 44.3% SC	Ergon	0.1	5 (12.64)^{b}	92.3	36.7 (37.25)^{b}	55.7
Plant Growth promoting Microorganisms	PGPM	2.0	15 (22.74)^{d}	76.9	76.3 (60.99)^{e}	7.9
Potassium Phosphonate	Akomin	0.3	10 (18.38)^{c}	84.6	46.7 (43.10)^{cd}	43.6
Propineb 70% WP	Anthracol	0.2	25 (29.98)^{ef}	61.5	40.0 (39.22)^{bc}	51.7
Trifloxystrobin 25% + Tebuconazole 55% WG	Nativo	0.1	30 (33.16)^{f}	53.8	53.3 (46.89)^{d}	35.6
Control	-	-	65 (53.75)^{g}	-	82.8 (65.71)^{f}	
CD (P ≤ 0.05)			3.64		4.46	

*Figures in parenthesis are arc transformed values

**Mean of three replications